High End Computing (HEC) Research and Development (R&D)

NITRD Agencies: NSF, OSD and DoD Service research organizations, DARPA, DOE/SC, NSA, NASA, NIST, DOE/NNSA, NOAA

HEC R&D agencies conduct and coordinate hardware and software R&D to enable the effective use of high-end systems to meet Federal agency mission needs, to address many of society's most challenging problems, and to strengthen the Nation's leadership in science, engineering, and technology. Research areas of interest include hardware (e.g., microarchitecture, memory subsystems, interconnect, packaging, I/O, and storage), software (e.g., operating systems, languages and compilers, development environments, algorithms), and systems technology (e.g., system architecture, programming models).

President's 2007 Request

Strategic Priorities Underlying This Request

Sustain U.S. leadership in HEC: Develop new generation of economically viable, high-productivity computing systems to meet Federal agencies' HEC needs, which will require managing rapidly increasing volumes of data and integrating multiscale (in space and time), multidisciplinary simulations

Hardware and software: Integrate innovations, especially language and development environments, to reduce barriers to use of systems that may have tens of thousands of processors and to increase the productivity of end-user applications

System prototypes: Develop, test, and evaluate robust, innovative HEC systems and software to reduce industry and end-user risk and to increase competitiveness. Industries using HEC include aeronautics, automobile, biomedicine, chemicals, petrochemicals, and pharmaceuticals.

Research pipeline: Continue HEC University Research Activity (HEC-URA) to help refill the workforce pipeline with highly skilled researchers who can develop future-generation HEC systems and software

Highlights of Request

HEC-URA: New R&D in file systems and I/O – NSF, DARPA, DOE/NNSA, DOE/SC, NSA

High-Productivity Computing Systems (HPCS) Phase III: Final phase of program to develop economically viable prototypes for national security and industrial user communities, to address all aspects of HEC systems (packaging, processor/memory interfaces, networks, operating systems, compilers, languages, and runtime systems) – DARPA, DOE/SC, DOE/NNSA, NSA, with NASA, NSF, OSD, other agencies

Advanced capabilities for scientific research: Expand SciDAC-enabling organizational resources including centers, institutes, and partnerships – DOE/SC, DOE/NNSA

Prototype research and evaluation: Prepare users for future generations of high-end systems and reduce procurement risk – DOE/SC

Vector processor system: Continue cooperative development – NSA, with other NITRD agencies

Quantum computing program: DARPA, NIST, NSA

Software environments: Develop common system software and tools for high-end systems – DOE/NNSA, DOE/SC, NSF, OSD

Weapons applications: Sustain advanced systems development effort to meet programmatic needs for increased productivity – DOE/NNSA

Planning and Coordination Supporting Request

Planning

Technical and planning workshops: HPCS Productivity Workshops, Storage and I/O Workshop to coordinate new HEC-URA file systems and I/O effort, HEC Requirements Workshop supporting new NSF HEC initiative – DARPA, DOE/NNSA, DOE/SC, NASA, NIH, NSA, NSF, OSD

Council on Competitiveness HPC Initiative: Fund studies, conferences, and educational activities to stimulate and facilitate wider usage of HEC across the private sector to propel productivity, innovation, and competitiveness – DARPA, DOE/NNSA, DOE/SC, NSF

Open-source software: Research to enable users to read, modify, and redistribute source code, fostering more efficient development and increased collaboration to improve software quality – DOE/NNSA, DOE/SC, NASA

Systems architecture

HEC hardware and software testbeds: Facilitate access, share knowledge gained and lessons learned – DOE/SC, NASA, NIST, NOAA, NSF, OSD

HPCS Phase III: DARPA, DOE/SC, DOE/NNSA, NSA, with NASA, NSF, OSD

Black Widow performance reviews: Assess progress on developmental milestones – NSA, with DARPA, DOE/NNSA, DOE/SC, NASA, NSF, OSD

Quantum information science: Study information, communication, and computation based on devices governed by the principles of quantum physics – DARPA, NIST, NSA, NSF

Systems software development

HEC-URA: Coordinate research in operating/runtime systems, languages, compilers, libraries – DARPA, DOE/NNSA, DOE/SC, NSA, NSF

HEC metrics: Coordinate research on effective metrics for application development and execution on high-end systems – DARPA, DOE/SC, NSF, with DOE/NNSA, NASA, NSA, OSD

Benchmarking and performance modeling: Collaborate on developing measurement tools to help improve the productivity of HEC systems – DARPA, DOE/NNSA, DOE/SC, NASA, NSA, NSF, OSD

File systems: Coordinate R&D funding based on a national research agenda and update agenda on a recurring basis – DARPA, DOE/NNSA, DOE/SC, NASA, NSA, NSF, OSD

Additional 2006 and 2007 Activities by Agency

NSF: University-based research on formal and mathematical foundations (algorithmic and computational science); foundations of computing processes and artifacts (software, architecture, design); emerging models for technology and computation (biologically motivated, quantum, and nanotechnology-based computing and design); distributed systems and next-generation software; data-driven science including bioinformatics, geoinformatics, and cognitive neuroscience; infrastructure development (create, test, and harden next-generation systems); and software and tools for high-end computing

OSD: Software Protection Initiative research in protection of critical defense software; applications software profiling and development; extend benchmarking and performance modeling to support system acquisitions and applications software development

DARPA: Architectures for cognitive information processing program – a new class of processing approaches, algorithms, and architectures to efficiently enable and implement cognitive information processing; begin transition of polymorphous computing architectures to DoD and commercial products; networked embedded systems technologies

DOE/SC: Research in programming models, performance modeling and optimization, software component architectures; development time and execution time productivity (with HPCS); data analysis and management, interoperability, software development environments

NSA: Eldorado – work with vendor on XT3 modifications, fully funding development in 2005-2006, available in 2006-2007

NASA: Participate in interagency coordination of architectures, testbeds, and system performance assessment

NIST: Architectures and algorithms for quantum computers; secure quantum communications

DOE/NNSA: Platforms; problem-solving environments; numeric methods; re-compete Alliance Centers program; user-productivity baseline in context of weapons simulations